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ABSTRACT

Technology can be an effective educational device if it is part of a well-conceived plan blending together other factors that also positively influence achievement. The body of research documenting the benefits of integrating technology into academic programs grows each day, particularly concerning the use of calculators and computers in the mathematics curriculum. Many obstacles exist to the integration of this technology. Cost is always cited as a major drawback, but faculty and student attitudes are important as well. In addition, there is a lack of agreement on the status of the latest technology. At the College of Lake County (CLC), the strategy for the integration of technology into the mathematics curriculum is straightforward. First, the college helps faculty develop a positive attitude regarding the use of technology. Second, this new attitude is used to help faculty develop competence in the use of the technology. Third, the use of the calculator is the primary focus which is supplemented by the use of the computer. Finally, the calculator is integrated into all levels of the curriculum, including remedial courses, rather than being forced upon the curriculum. Students at CLC have shown more interest in mathematical topics when the course is calculator-based. Faculty also benefit from the calculator-based curriculum. Ultimately, technological integration in mathematics courses is only as good as the people effecting the integration; thus, administrators must provide proper incentives for faculty, and faculty must make an effort in such seemingly straightforward areas as choosing a calculator for their classes. (JMC)

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A Cost-Effective Strategy for Integrating Technology into the Advanced and Remedial Mathematics Curriculum in the Community College

Paper Presented at the:
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Effectiveness and Student Success
January 27, 1992

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Winter Institute on Community College Effectiveness and Student Success
January 27, 1992

A Cost-Effective Strategy for Integrating Technology into the Advanced and Remedial Mathematics Curriculum in the Community College

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1. Why is technology needed?

    a. Poor achievement levels by students.
    b. High attrition rates in mathematics classes.
    c. Research documents the positive role of technology.
    d. National organizations recommend it.

        1. National Council of Teachers of Mathematics (NCTM).
        2. American Mathematical Association of Two Year Colleges (AMATYC).
        3. Mathematical Association of America (MAA).

2. Obstacles to the integration of technology.

    a. Cost - hardware, software and training.
    b. Faculty attitudes
        1. What is important in mathematics?
        2. Are we losing something by de-emphasizing paper and pencil methods?
    c. Student attitudes will reliance on a calculator hurt me at a university?
    d. Lack of agreement on the latest technology.

        1. We need to wait until the technology has evolved before we commit ourselves.
        2. Calculator A is better than calculator B. (Actually, it is more important that everyone have the same machine than it is that they have the best machine).

3. What technology is available?

    a. Graphics software - MathCad or AutoCad. (Sophisticated)
    b. Computerized algebra systems (CAS) - Derive, Mathematica.
    c. Graphics calculators - Casio 7000, 7700; TI-81.
    d. Scientific calculators - Casio, Sharp, TI.
    e. Use of calculators is recommended for two reasons.

        1. A student can keep a calculator and use it in later mathematics (or other) courses. This is often not possible with college purchased software.
        2. Student purchase of the calculator takes some of the financial burden of technology use off the college.

4. What is the strategy?

   a. Develop positive faculty attitude regarding the use of technology.
   b. Develop faculty competence in the use of technology.
   c. Emphasize the use of the calculator and supplement with the computer.
   d. Integrate rather than attach technology to the curriculum.

5. At what levels should integration take place?

   a. Advanced level. (Limited to this level at too many schools).
   b. Remedial level. (Equity demands it be done here).
   c. At other appropriate places in the curriculum.

6. How should integration take place?

   a. Faculty must be committed to technology.

      1. equipment must be made available to use.
      2. incentives to experiment must be made available. (released time, stipends, equipment at home).
      3. faculty must be willing to change their view of what is important in mathematics.

   b. How to prepare faculty.

      1. internal workshops by expert faculty.
      2. workshops conducted by software manufacturers and textbook publishers.
      3. weeklong NSF chautauquas and AMATYC workshops.

   c. Requirements for faculty who receive released time to use technology in their courses.

      1. Meet weekly with other faculty in same situation to discuss what works and what does not.
      2. Keep a diary of activities.
      3. Share prepared exercises and instructional aids which emphasize technology.

7. Things which must be done differently in a technological environment.

   a. Remedial

      1. Different ways of computing the GCF and LCM (Integrate rather than attach).
      2. Computations with common fractions.
      3. Developing "number sense" with electronic images.

b. College algebra and trigonometry (or precalculus). Graphing calculator and CAS.

1. Matrix algebra.
2. How many solutions does $\sin(x) = \log_{5\pi}(x)$ have?

c. Calculus (Graphing calculator and CAS)

1. Maxima and minima.
2. Concavity of graphs.

8. What are the actual costs?

a. Calculators - scientific $10-$15, Graphing $75-$100.
b. Software - Derive $135-$200, Mathematica $500-$900, MINITAB $40 (Student version) - $500 (Full version).
c. Conference attendance - $1000-$1500 per faculty (total expense).

9. Differences between a calculator based curriculum and the current curriculum.

a. Homework and test exercises must be more challenging. They cannot be mere calculations.
b. More emphasis on approximating answers.
c. One solution method works for all equations. Specialized techniques for certain types of systems no longer needed.

10. Benefits of the calculator based curriculum.

a. Students

1. more in-class interest.
2. greater understanding and interpretation of graphs.
3. inconclusive results on achievement level.

b. Faculty

1. Revitalization for faculty who have taught the same way for years.
2. Requires all faculty to analyze current curriculum and discuss what is important.
3. Important question: <u>How much symbol manipulation is required to internalize mathematical concepts</u>?

11. Summary questions.

a. What does the future hold? More technology rather than less.
b. Does a student with a calculator have an advantage? Yes. This is why equity demands that all students have a calculator.
c. Is it unfair to expect economically disadvantaged students to buy a calculator?

1. No. The current price of a scientific calculator is so reasonable that price is no longer an obstacle.
2. No, since requiring a calculator places it among the things that financial aid will pay for.

d. The new viewpoint.

1. Treat the calculator like a textbook. If it is standardized for a class then teaching can be more effective.
2. All students, especially remedial students must have access to this technology.
3. Current research has shown that a principal factor in increasing achievement at all levels is student-teacher interaction. Integration of any technology must be done in a way that builds on this fact. Technology will not be effective if a goal of its use is to replace this factor. which research at all levels documents as effective.

Winter Institute on Community College
Effectiveness and Student Success
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A Cost-Effective Strategy for Integrating Technology into the Advanced and Remedial Mathematics Curriculum in the Community College

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The introduction of technology in the various levels of American education has had marginal effects on achievement at best. For example, many had high hopes for improvement in learning because of television. Similarly, the computer was hailed as a solution to underachievement. Unfortunately, though both these innovations have had positive effects on our educational system, they have not lived up to the hype surrounding their introduction.

Because of this, the educational establishment can be forgiven some healthy skepticism when yet another technological innovation comes upon the scene. Various types of calculators promise to simplify mathematical computations for students and allow them to concentrate on concepts. The basis of this claim is the belief that the drudgery of long and involved calculations causes students to dislike mathematics. Removing this drudgery may do away with a substantial impediment to educational achievement in mathematics. Our previous experience with technology allows us reasonable doubts when these claims are made.

Recognition of the fact that calculators (or computers) are no panacea is the beginning of wisdom in their appropriate use.

Expecting too much from them is as bad as expecting too little. Let us keep this in mind as we review some of the reasons this new technology can be expected to help in increasing achievement.

Let us also keep in mind that the most persistent finding of research in higher education is that formal and informal instructor-student interaction positively influences achievement in every post-secondary setting. This fact must be kept in mind when attempting to use technology. That is, technology must be used in a way that complements instructor-student interaction. Technology will not be effective if used in a way which attempts to replace this interaction.

With the above caveats in mind, we must emphasize that technology can help if it is part of a well-conceived plan blending it with other factors that also positively influence achievement. The body of research documenting the benefits of integrating technology into academic programs grows each day. National organizations such as the National Council of Teachers of Mathematics (NCTM), the American Mathematical Association of Two-Year Colleges (AMATYC) and the Mathematical Association of America (MAA) all have position papers recommending the use of calculators and computers in the mathematics curriculum.

There are many obstacles to the integration of this technology. Cost is always cited as a major drawback, but faculty and student attitudes are important as well. Faculty have varying views about what is important in mathematics and fear that something valuable is lost when paper and pencil methods are de-

emphasized. The role that symbol manipulation using paper and pencil methods plays in learning mathematical concepts is still not well understood and mathematicians are understandably reluctant to abandon such methods.

In addition, there is a lack of agreement on the status of the latest technology. Some feel that further evolution is necessary before a wholesale commitment is made. Such persons feel that the ultimate calculator or computer must be available or else we are condemned to constant cycles of purchasing less than the best. They believe that the best is the only option. Our work at the College of Lake County suggests that it is more important for all students in a class to have the same calculator than it is for them to have the best calculator.

It is the purpose of this paper to emphasize this emerging calculator technology as a starting point for all mathematics students. Depending upon the course, either a graphing calculator or a scientific calculator can be used. Calculators are emphasized because a student can keep a calculator and use it in many classes throughout a college career. Additionally, unlike the purchase of computers which is borne by the educational institution, the purchase of the calculator is borne by the student. This frees institutional monies for other purposes.

The strategy for the integration of technology into the mathematics curriculum is quite simple. First, we need to help faculty develop a positive attitude regarding the use of technology. Second, this new attitude must be used to help

faculty develop competence in the use of the technology. Third, the use of the calculator is the primary focus which is supplemented by the use of the computer. Finally, we need to integrate the calculator into the curriculum rather than forcing it on the existing curriculum without regard as to whether or not it fits.

The proposed integration must take place at all levels of the curriculum. This includes the remedial level, not just the upper end of the curriculum as is currently the case. Remedial students are exceptionally in need of this valuable tool. Equity demands that it not be limited to those students who experience success in mathematics but be available to those who have the most difficulty.

When the calculator is used, many things must be done differently. In the remedial curriculum, problem solving skills must be emphasized, not just computation. For students whose previous experience with mathematics has been failure, the calculator gives the opportunity to develop arithmetic skills in a way different from the rote memorization methods used in the past. The calculator can be used to develop "number sense". This is a recognition of the relationships existing among numerical quantities which allow one to estimate the reasonableness of an answer.

In more advanced courses, the graphing calculator can be used to draw graphs of complicated equations. It also replaces the long list of special methods used to solve different

varieties of equations. With the calculator only one method is needed. All systems of equations can be solved by determining the intersection points of their graphs.

The costs of the calculators are quite reasonable, especially when contrasted with the costs of outfitting a computer lab with machines and appropriate software. Scientific calculators used in remedial courses cost from $13.00 to $29.00. In fact, the cost of a calculator is often less than the cost of a textbook for a course. Graphing calculators cost from $75 to $110.

In a calculator based curriculum the homework and test exercises must be more incisive than is presently the case. Exercises cannot be limited to straight computation, but must involve relationships. There must be more emphasis on developing estimation skills so an answer can be checked to determine if it is reasonable.

Students at the College of Lake County have shown more interest in mathematical topics when the course is calculator based. They develop the ability to analyze and interpret graphs and do not fear long and involved calculations. The question as to whether the achievement level has increased is still open. More study is needed to document exactly what has occurred in this area.

Faculty also benefit from the calculator-based curriculum. It is a breath of fresh air for persons who have taught for many years without modifying their syllabus, curricular aids or test

structure. It also requires faculty to begin an analysis of what they regard as important in mathematics and to grapple with the question: How much symbol manipulation by manual means is required to internalize mathematical concepts?

The future holds many possible uses for calculators as long as they are not viewed as some kind of mathematical cure-all. It is clear that there will be more rather than less uses of this technology, so students must be prepared. Students will purchase and make use of calculators, it is up to us to make sure they learn to use this tool correctly.

It is helpful to think of the calculator in the same way as we think of a textbook. That is, a certain book is specified for each class after the faculty member teaching it has searched through what is available. A calculator should be selected in the same way. The choice should not be left to the student. A calculator should be specified after a reasonable search and the students required to purchase it. This means that everyone in a class will have the same calculator, making instruction in proper use much easier.

As stated earlier, the technology must be integrated into the course rather than forced on it. This means that the strengths and weaknesses of the calculator must be considered in deciding how it is to be used. It cannot simply be forced on the current syllabus, it must be integrated into it in ways that use its strengths.

Finally, the calculator must be used in a way that

complements the teacher. Student-teacher interaction is one of the most powerful forces that we have going for us in the educational process. We must be careful that we do not try to replace it with over-reliance on technology. We must blend the calculator with the other things that we know enhance mathematical achievement.

Technological integration in mathematics courses is only as good as the people effecting the integration. If faculty are given the incentives to learn and use technology in their courses they will do so. They will have these incentives only if we in administration provide them. As with all innovations, sound planning based on a sound strategy is necessary. If we are to foster higher achievement in mathematics, it all comes down to how hard we are willing to work.

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